EVIDENCE-BASED MEDICAL EXAMINATIONS FOR HAZARDOUS MATERIALS FIREFIGHTERS

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supported by NIOSH NORA grant OH03729

Medical Examinations for Firefighters: Background

- Medical Exams for Fitness for Duty and Surveillance of health effects are recommended by the NFPA and most medical authorities.
- Pre-placement and periodic examinations of fitness for duty are now required for firefighters in Massachusetts.
- The OSHA standard on Hazardous Waste Workers (29 CFR 1910.120) requires medical exams and includes hazardous materials response firefighters.
- An identical U.S. Environmental Protection Agency (EPA) standard applies to state and municipal employers in states without designated OSHA programs.

Medical Examinations for Firefighters: Background

- The OSHA standard requires pre-assignment examinations and periodic exams, but required testing is not specified.
- Like other similar pre-placement and periodic exams in occupational medicine, firefighter examinations are frequently performed, but their results and content are rarely studied.
- Our research under a NORA grant has studied firefighter medical examinations to develop an evidence-based framework to improve both medical surveillance and fitness determination.

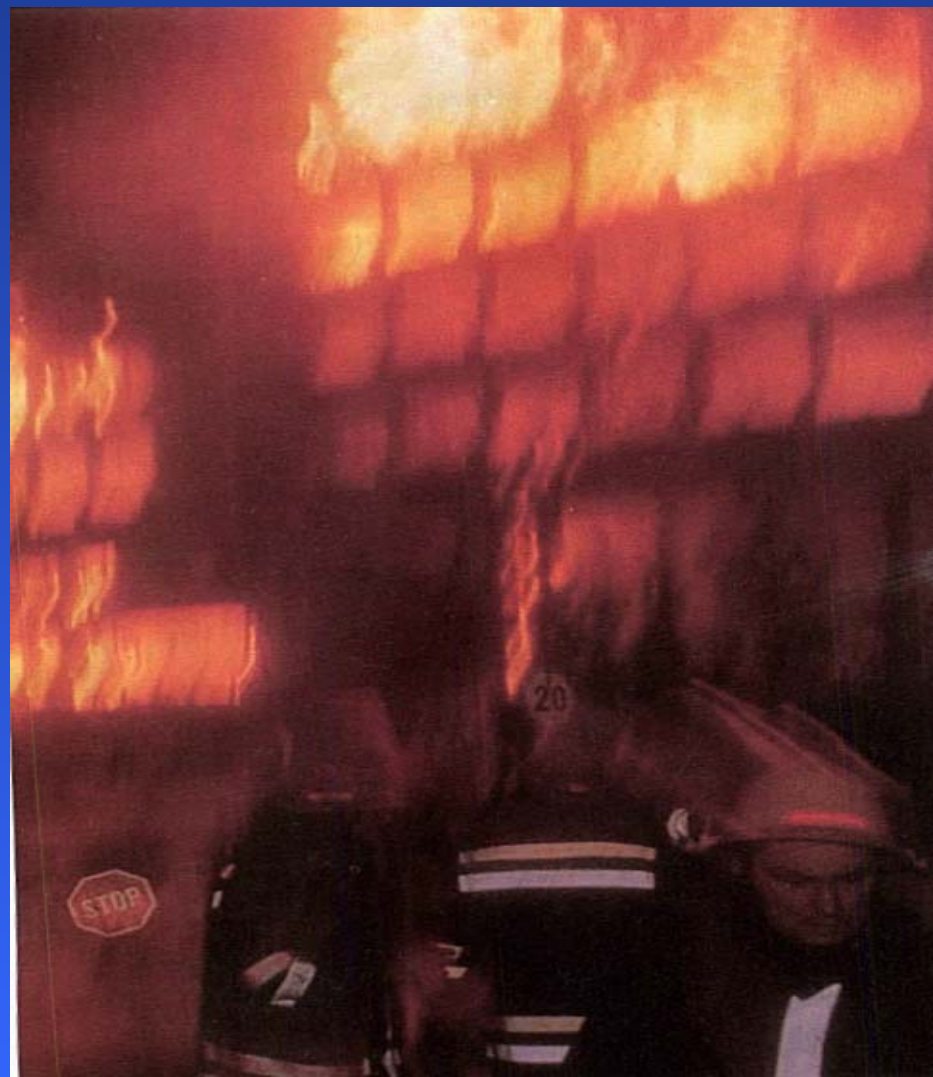
Medical Examinations for Hazardous Materials Firefighters: Surveillance of Health Effects

- Because of a myriad of potential exposures, most hazmat surveillance programs include end-organ effect markers (complete blood counts, renal and hepatic function tests, spirometry, etc.).
- Authorities also recommend similar testing for hazardous waste workers and for other firefighters.
- Since 1996, we have examined 356 hazardous materials firefighters, most annually.

A Prospective Study of Hepatic, Renal and Haematologic Surveillance in Hazardous Materials Firefighters

Kales et al Occup Environ Med 2001:58:87-94.

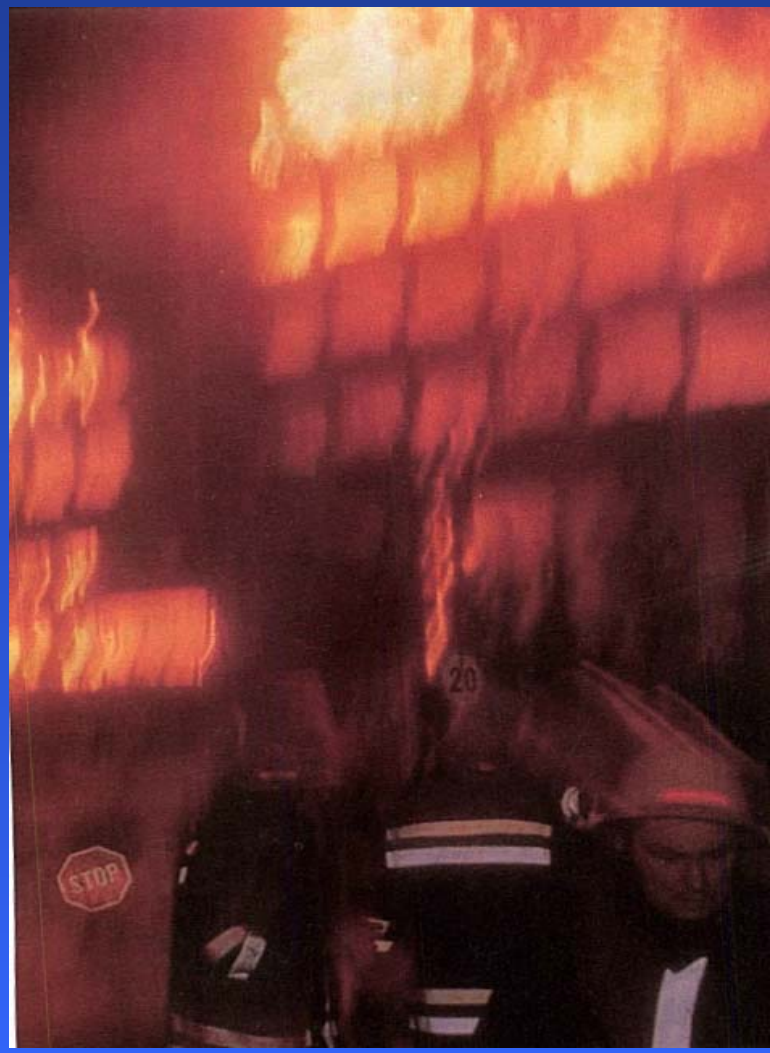
- **Objectives.**
- To evaluate possible health effects of hazardous materials duty as measured by biochemical markers in a large cohort over two years and in a subcohort over five years.



A Prospective Study of Hepatic, Renal and Haematologic Surveillance in …: Methods

- We analyzed hepatic, renal, and hematologic testing from 1996-98 in 288 hazardous materials technicians (81%) and 68 support members (19%) and the same markers in a subcohort of the technicians (n=35) from 1993-98.

- We considered support members as controls because they are also firefighters, but have a low potential for exposure to hazardous materials.



Hepatic Surveillance in Hazardous Materials Firefighters

Liver Function Tests (mean +/- S.D)

Variable	Year	Technicians	Support	P-value
Alk Phos (U/L)	Year 1	82 +/- 21 N=266	84 +/- 22 N=70	0.491
	Year 3	82 +/- 20 N=269	84 +/- 19 N=63	0.339
AST (U/L)	Year 1	25 +/- 10 N=266	24 +/- 9 N=71	0.360
	Year 3	25 +/- 10 N=269	25 +/- 9 N=63	0.805
ALT (U/L)	Year 1	36 +/- 20 N=266	35 +/- 21 N=71	0.652
	Year 3	36 +/- 18 N=269	38 +/- 18 N=62	0.418

A Prospective Study of Hepatic, Renal and Haematologic Surveillance…Findings

- We found no cross-sectional differences between technicians and the support referents.
- After adjustment for a change in laboratory, we found no significant longitudinal changes within groups except for creatinine (Cr)
- Because Cr decreased (improved) in both groups, and we found no differences between groups, we believe that this change was not exposure related.

Hepatic, Renal and Haematologic Surveillance in Hazardous Materials Firefighters: Conclusions

- **Negative results are consistent with previous findings in hazardous waste workers (Favata and Gochfeld AJIM 1989;15:255-265.)**
- **Current protective equipment and procedures including decontamination appear effective.**
- **Hematologic, hepatic, and renal testing is not required on an annual basis.**

- **<u>Our current recommendations:</u> Determination of baseline measurements for comparison with values obtained after significant exposures or illness, and periodic testing about every 3 years.**

Hepatic, Renal and Haematologic Surveillance in Hazardous Materials Firefighters: Conclusions

- **Irritants and corrosives are the most common substances in hazardous materials releases, but are unlikely to be detected by these tests.**
- **Common health problems often produce abnormalities. Therefore, these tests are not sensitive or specific markers of hazardous materials exposure.**
- **In practice, however, we have continued annual testing at the request of the firefighters. They tend to overvalue normal results on these parameters as ruling out the possibility of present and future exposure-related health effects.**

Injuries due to Hazardous Materials Accidents

Kales et al. Ann Emerg Med 1997;30:598-603.

- Inhalation of irritants is the most common health effect of hazardous materials releases in our, ATSDR and other series.
- Pulmonary irritants can affect pulmonary function.
- Spirometry is recommended by NFPA as well as other experts.
- Most programs include spirometry in firefighter and hazmat examinations.

Table 3.

Medical effects encountered among victims of hazardous materials incident.

Type of effect	Incidents (No.)	Symptomatic victims (No.)
Respiratory irritation	11	108*
Shortness of breath	10	100
Physical trauma	8	11
Headache	5	38
Dizzy	3	25*
Chemical burn	3	15
Skin irritation	3	3
Chest pain	2	74
Nausea	2	9*
Smoke inhalation	1	4
Carbon monoxide poisoning	1	2
Heat stress	1	Unspecified
Cold injury	1	Unspecified
Numbness	1	Unspecified

*Total is an underestimate because of unspecified number of transports in some incidents.

Spirometric Surveillance in Hazardous Materials Firefighters: Does Hazardous Materials Duty Affect Lung Function?

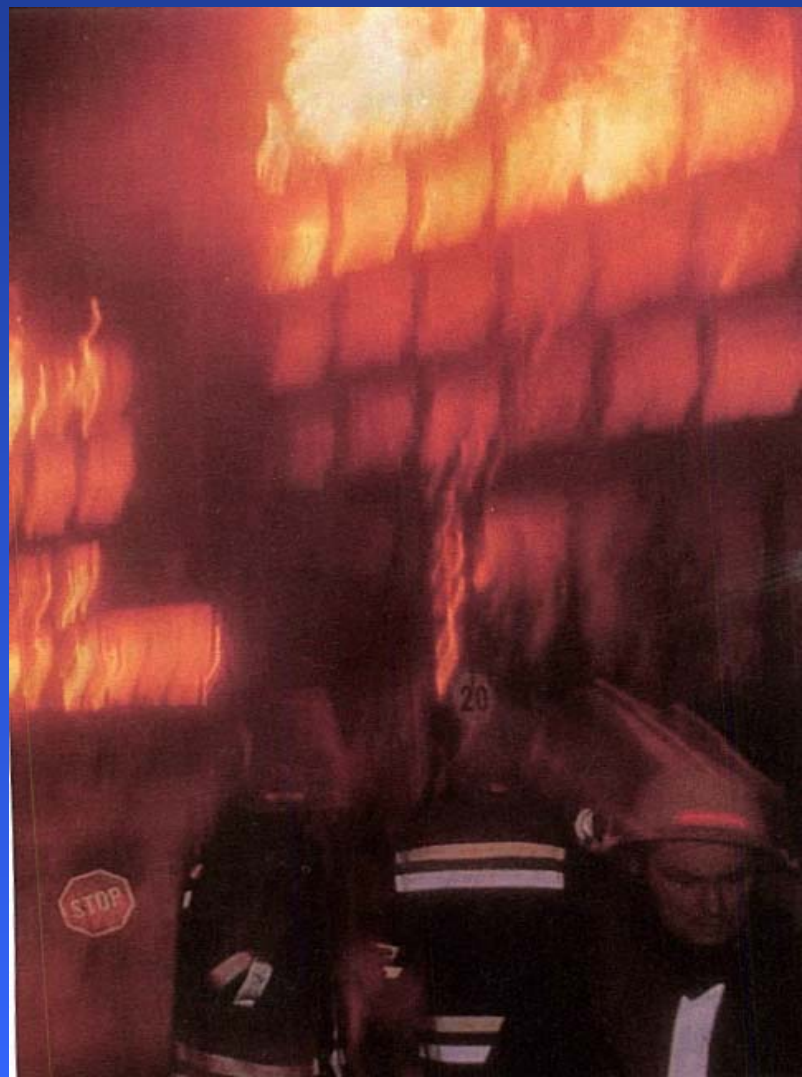
Kales et al. J Occup and Environ Med 2001 (in press)

To evaluate possible health effects of hazardous materials duty on lung function as measured by Spirometry in a large cohort over three years and in a subcohort over six years.

Prospective Study of Spirometric Surveillance... 1996-1999: Methods

- Analyzed Spirometry (%FVC and %FEV1predicted) from 1996-99 in 351 male firefighters including 276 hazardous materials technicians (79 %) and 75 referent support members (21%).

- We also analyzed %FVC and %FEV1 predicted in a subcohort of the technicians (n=35) from 1993-99.



Technicians vs. Controls at each Examination

Variable	Year	Technician	Support	P-Value (2-tailed)
FVC (% predicted)	1996-7	103 +/- 13 (n=263)	102 +/- 10 (n=66)	0.719
	1997	102 +/- 13 (n=168)	98 +/- 10 (n=40)	0.053
	1998	103 +/- 13 (n=261)	100 +/- 9 (n=60)	0.040
	1999	103 +/- 12 (n=243)	98 +/- 10 (n=51)	0.003
FEV1 (% predicted)	1996-7	102 +/- 13 (n=263)	103 +/- 12 (n=66)	0.998
	1997	103 +/- 13 (n=168)	102 +/- 12 (n=40)	0.690
	1998	101 +/- 14 (n=261)	98 +/- 13 (n=60)	0.165
	1999	100 +/- 13 (n=243)	96 +/- 14 (n=51)	0.049

Time Analyses: Remained on teams and did not change positions

Variable	Job Type	1996-97	1998	1999	Total	ANOVA p-value
FVC (% predicted)	Technician	103 +/- 13 (n=225)	103 +/- 13 (n=226)	103 +/- 13 (n=228)	103 +/- 13 (n=679)	0.780
	Support	100 +/- 10 (n=46)	99 +/- 9 (n=47)	98 +/- 10 (n=46)	99 +/- 10 (n=139)	0.568
	Total	103 +/- 12 (n=271)	102 +/- 12 (n=273)	102 +/- 12 (n=274)	102 +/- 12 (n=818)	0.621
FEV1 (% predicted)	Technician	103 +/- 13 (n=225)	101 +/- 14 (n=226)	100+/- 13 (n=228)	101 +/- 14 (n=679)	0.029
	Support	100 +/- 12 (n=46)	99 +/- 13 (n=47)	97 +/- 13 (n=46)	99 +/- 12 (n=139)	0.433
	Total	103 +/- 13 (n=271)	100 +/- 14 (n=273)	100 +/- 13 (n=274)	101 +/- 13 (n=818)	0.014

Spirometric Surveillance: Conclusions

- Although respiratory irritants are the most common exposures, current protective equipment and procedures appear effective.
- Widespread use of SCBAs (respiratory protection), seems to account for the lack of chronic effects in several recent studies of pulmonary function in firefighters
- Acute effects from smoke exposure have consistently been demonstrated, however.
- The short period of follow-up, and the small excess decline in FEV1 for the entire cohort are other reasons to continue spirometry.
- Therefore, we continue to recommend yearly spirometry.

Medical Examinations for Firefighters: Fitness for duty

- Fitness for Duty examinations may be thought of as surveillance for problems that may compromise personal and/or public safety.
- Looking for medical/physical conditions that interfere with the safe performance of essential job functions (e.g. poor vision) or put the worker at risk of sudden incapacitation (e.g. seizures, heart disease).
- Fitness for duty criteria: for many criteria, limited evidence is available to support their use and even less data to support or refute cutoff values beyond which point a firefighter is suggested to become unfit for duty.

FIREFIGHTERS' BLOOD PRESSURE AND EMPLOYMENT STATUS ON HAZARDOUS MATERIALS TEAMS IN MASSACHUSETTS : A Prospective Study (in preparation)

- The NFPA, Massachusetts and DOT have blood pressure guidelines for firefighters and commercial drivers, respectively. Cutoff criteria are extrapolated from non-occupational investigations and consensus.

- NFPA: <180/100 mm Hg and no target organ damage.
- Massachusetts: upon initial hire, <160/100.
- DOT: </= 160/90.

(May provisionally qualify if, 161-180/91-104, but must be disqualified when the systolic blood pressure >180 or diastolic >104)

FIREFIGHTERS' BLOOD PRESSURE AND EMPLOYMENT STATUS...

- Which guidelines, if any are sensitive/specific and fair?
- The lack of supportive evidence reinforces examiners' reluctance to exclude someone from his/her job based on a single examination finding.
- Therefore, we undertook this study to attempt to develop an evidence-based guideline for resting blood pressure among firefighters.
- Firefighters were followed for a maximum of 4 years: from 1996 until the 2000 examination or until some adverse outcome.

Adverse Outcome Events & BP Categories

- **ADVERSE EVENTS:** death, "injured on duty" status, termination of duty, resignation/retirement and major incident cardiovascular events (new myocardial infarction or new coronary heart disease, or significant arrhythmia)

- **BLOOD PRESSURE:**

1) **Normal blood pressure** at every examination (SBP<140 and DBP<90).
2) **Stage I hypertension (140</=SBP<160 and/or 90</=DBP<100)** at baseline or during follow up examinations, but no stage II hypertensive readings.
3) **Stage II hypertension or higher (SBP>/=160 and/or DBP>/=100)** at any examination (1996-99).

		Blood pressure categories (mm Hg)			
Adverse Events 1996-2000	**N**	**Normotensive at all time points (n=215)**	**Some Stage I hypertensive readings (n=93)**	**Any Stage II hypertensive readings (n=26)**	**p-value**
Adverse Events*	334				
No event		180 (84%)	84 (90%)	18 (69%)	0.029
Event		35 (16%)	9 (10%)	8 (31%)	
Adverse Events (on BP med excluded)[1]	314				
No event		178 (85%)	75 (90%)	13 (62%)	0.005
Event		32 (15%)	8 (10%)	8 (38%)	
Adverse Events (Excludes BMI<30)[1]	112				
No event		46 (77%)	34 (87%)	7 (54%)	
Event		14 (23%)	5 (13%)	6 (46%)	0.013
Adverse Events (Excludes BMI<30 or on BP med excluded)[2]	102				
No event		46 (78%)	28 (85%)	4 (40%)	
Event		13 (22%)	5 (15%)	6 (60%)	0.042

Adverse Events prior to the next examination per Person Years (p-yrs) of Follow-up

- Normal blood pressure: 3.8/100 p-yrs (40/1049 p-yrs).
- Stage I hypertensive: 4.5/100 p-yrs (8/176 p-yrs).
- Stage II hypertensive: 10.8/100 p-yrs (4/37 p-yrs) ($p<0.05$, compared to normotensive and stage I pooled).

- Among obese stage II hypertensives not on medication, the rate of adverse events was 21 events per 100 person-years. ($p<0.05$, compared to the pooled rate for obese firefighters in other two groups (5.3-8.1 per 100 person-years).

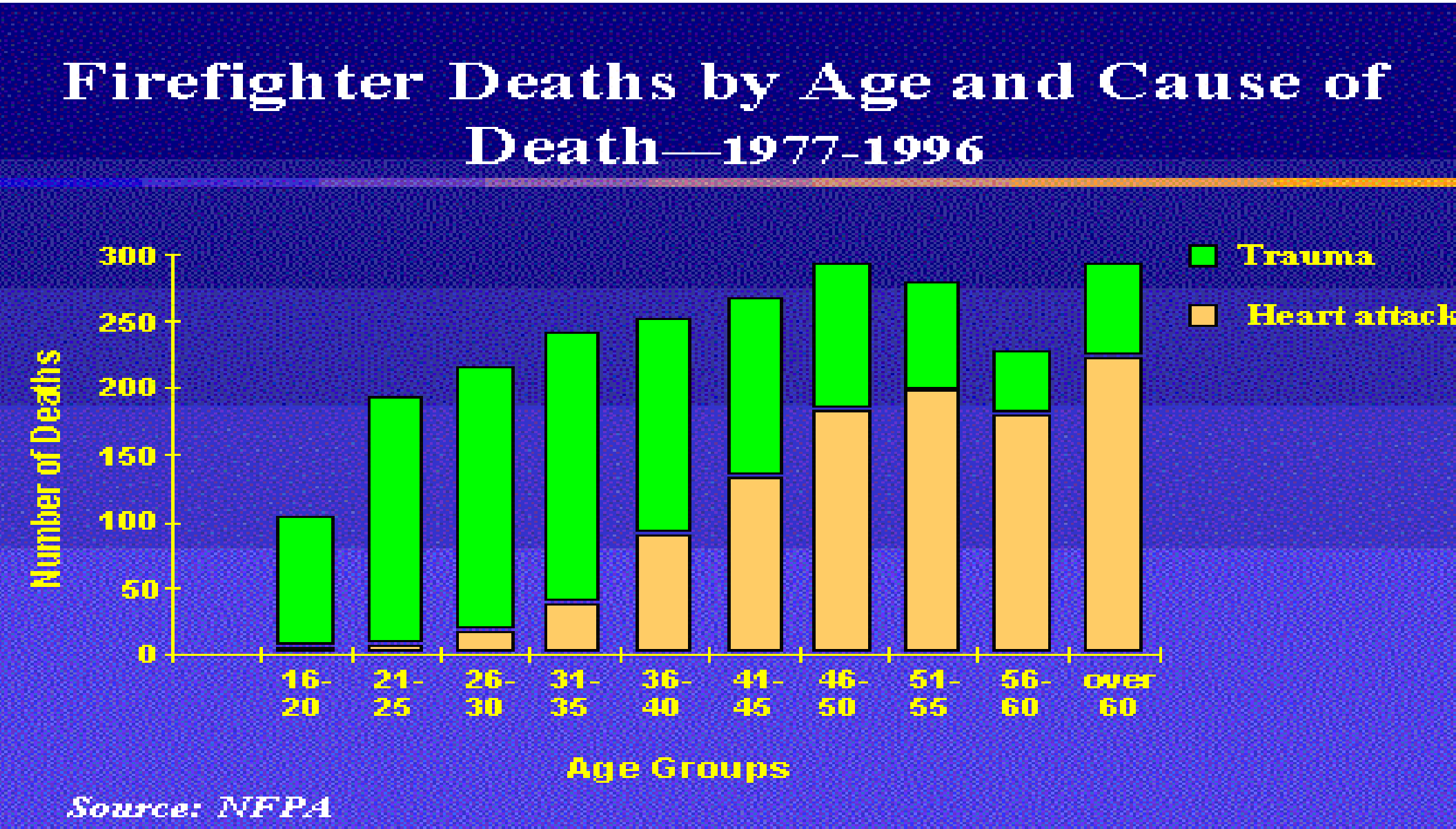
FIREFIGHTERS' BLOOD PRESSURE AND EMPLOYMENT STATUS…Preliminary Conclusions

1) Our results support using 160/100 mm Hg as the cutoff criterion for acceptable resting blood pressure among firefighters.

2) Obese firefighters (BMI>/=30) with Untreated Stage II hypertension are at the highest risk.

3) Firefighters with blood pressure readings >/=160/100 should receive further evaluation and demonstrate improved blood pressure control prior to receiving clearance as fit for duty.

Another goal of fitness determination is the identification of individuals at high risk for incapacitation and death



Fatalities and Increasing Age

- **The on duty fatality rate is over 6 times higher for firefighters over 60 years old and 3 times higher for those 50-59 years old compared with those 20-39 years old.**

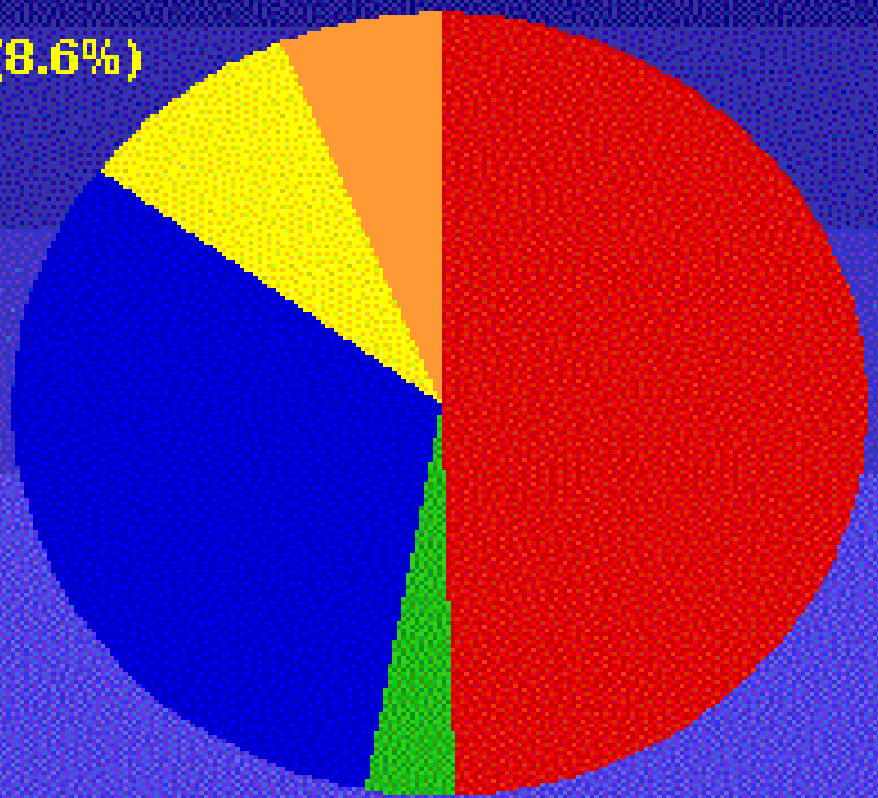
- **Myocardial infarctions are the number one cause of on duty death among firefighters accounting for almost half of all deaths overall and about two-thirds of deaths in firefighters over 45 years old.**

TABLE II. Predicted Coronary Heart Disease Risk of Firefighter Age Groups (Males Only), Hazardous Materials Firefighters, Massachusetts

Correlates of Fitness for Duty …Kales et al AJIM. 1999;36:618-629.

Age group	N	Mean predicted 10 year CHD risk	Average 10 year CHD risk (Framingham study)
<30	6	3.0 ± 0.9%	NA
30–34	35	4.3 ± 1.5%	3%
35–39	36	5.1 ± 2.4%	5%
40–44	36	7.1 ± 2.9%	7%
45–49	30	10.8 ± 3.5%	11%
50–54	10	14.4 ± 5.4%	14%
55–59	1	13.0	16%
Total	154	7.1 ± 4.2%	NA

Prior Physical Problems —1977-1996



Source: NFPA

Myocardial Infarctions among Firefighters

- Over 90% of these deaths occurred in persons with known heart disease or significant risk factors.
- Health and fitness promotion and medical screening could have important impacts.

- NIOSH preliminary results from review of 1995-98 firefighter fatalities suggest that the absence of adequate medical screening programs may contribute to heart attack fatalities.

Maximal exercise testing as a predictor of risk for mortality from coronary heart disease in asymptomatic men.

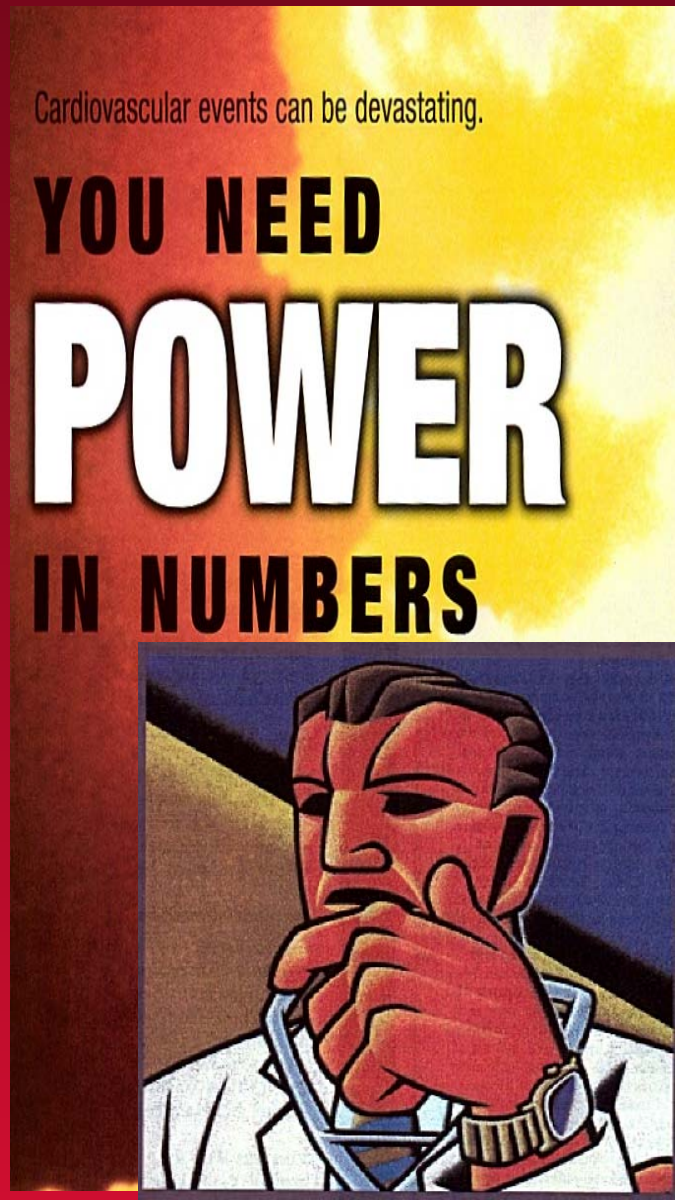
Gibbons et al. Am J Cardiol 2000;86:53-58.

- Study of >25,000 men, 20-82 years old (mean age 43)
- Average follow-up 8.4 years, with 158 cardiac deaths.
- The sensitivity of an abnormal exercise test was 61% for predicting CHD and more predictive in those with CHD risk factors.

Cardiac Risk Factors	Relative Risk of CHD Death
None	21 (6.9-63.3)
1	27 (10.7-68.8)
2	54 (21.5-133.7)
3	80 (30.0-212.5)

EXERCISE STRESS TESTING: PRELIMINARY SUGGESTIONS

- The small absolute number of MI's (about 40-45 in us) may preclude universal testing above age 40.
- All persons with CAD, other vasocclusive dz need an ETT and/or other objective testing.
- The lack of symptoms by itself should not obviate an ETT.
- Strongly consider ETT for all persons ages >/=50.
- ETT for selected younger firefighters based on cardiac risk profiles.
- Case-control and prospective study in firefighters are needed to characterize those at highest risk and define the role of ETT.



We thank the Firefighters who are members of Massachusetts Hazardous Materials Response Teams for their ongoing participation and support.

This presentation is dedicated to the memory of those Firefighters who gave their lives to save others at the World Trade Center, and all Firefighters who have died or have been injured in the line of duty.